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Lifetime prevalence of exostoses in New Zealand surfers

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ABSTRACT

INTRODUCTION: External auditory exostosis (EAE) is a benign, irreversible bony outgrowth that arises from the temporal bone. EAE projects into the external ear canal, potentially causing recurrent otitis externa and conductive hearing loss.

AIM: To determine lifetime prevalence of EAE in New Zealand (NZ) surfers.

METHODS: This study used an online national survey.

RESULTS: Respondents were 1376 NZ surfers (recreational = 868, competitive = 508). Mean surfing experience was 16.2 years. Most self-classified as advanced surfers (36.5%), followed by intermediate (30.2%), expert (20.1%) and beginner (13.2%). Surfers reported an average of 214.2 h surfing (28.6% during winter) for the previous year. Overall lifetime prevalence of EAE was 28.9% (32.1% male, 14.6% female $P < 0.001$), with the highest proportion of EAE was observed bilaterally (21.3%). Competitive surfers reported a significantly ($P < 0.001$) higher lifetime prevalence of EAE than recreational surfers (45.3% vs. 19.2%). A significantly higher ($P < 0.001$) lifetime prevalence of EAE was identified as skill level increased (7.1% in beginners to 55.6% in experts) and a two-fold increase ($P < 0.001$) of EAE in the highest (vs. lowest) quartile of surfing exposure. Neither winter surfing exposure nor which Island surfed were associated with EAE prevalence.

DISCUSSION: Although not as prevalent as in previous NZ research using otologic examinations, this study indicated that almost one-third of NZ surfers reported having had a diagnosis of EAE. Regular general practitioner otologic assessment and advice on appropriate prevention strategies for patients who surf may help prevent large lesions, recurrent ear infections and progressive hearing loss.

KEYWORDS: Auditory exostoses; surfing; surfers ear; otology; preventive medicine; sports medicine

Introduction

External auditory exostosis (EAE), also known as Surfers Ear, is an abnormal broad-based projection of the temporal bone into the external auditory canal (EAC).[1] Although benign and usually asymptomatic, it is an irreversible condition that can lead to potentially serious complications. Commonly found bilaterally, with multiple lesions, patients can present with chronic cerumen impaction, recurrent otitis externa, otalgia and conductive hearing

WHAT GAP THIS FILLS

What is already known: External auditory exostosis (EAE) is a reactive process that has been documented in surfers in Australia, Japan, Ireland, USA and the UK who were repeatedly exposed to water temperatures below 19°C. New Zealand (NZ) water temperatures range from 9.5°C to 21°C depending on latitude and season. Therefore, NZ surfers are likely to be susceptible to EAE.

What this study adds: This research identified a 29% lifetime prevalence of EAE in NZ recreational and competitive surfers, highlighting the importance of regular otologic screening by general practitioners of patients who surf to identify EAE in the early stages and promote preventive care measures.

impairment due to stenosis of the EAC.[2] When assessed by otoscopy, the prevalence of EAE in surfing populations ranges from 38% to 80%.[2,3]

Surgical removal is the only treatment of auditory exostosis.[1] However, the procedure does not prevent recurrence, is technically challenging and associated with complications such as hearing loss, tympanic membrane rupture, damage to the facial nerve and stenosis of the EAC.[4,5] Therefore, surgery is usually reserved for patients with severe and symptomatic lesions. Prevention of EAE remains insufficiently investigated. However, regular use of protective equipment, such as earplugs, hood or swim cap, is recommended to assist in preventing the occurrence of auditory exostoses.[6,7]

The precise mechanism for the development of EAE is not fully understood. However, it is believed that cold conditions stimulate osteoblastic activity, leading to exostoses development.[8,9] Consequently, exposure to cold water and wind are recognised risk factors affecting EAE prevalence and severity. Additionally, EAE incidence is correlated with the amount of time spent in the water, with risk increasing after five sessions of surfing per month, and significantly increasing after 5 years of surfing.[10,11]

Sea water surface temperatures in New Zealand (NZ) range from 9.5°C to 21°C depending on latitude and time of the year, with annual mean temperatures of ~15 – 17°C north of the Wellington region, 13 – 14°C in Wellington, Canterbury and Westland, and 12°C in Otago and Southland.[12,14] This temperature range has been associated with high prevalence of exostoses.[9,15,16] However, in NZ, only one study, published in 1998, has investigated the epidemiology of EAE.[17] The research was conducted in 1994 and objectively assessed 92 amateur surfers and surf lifesavers via otoscope, in Dunedin (Otago region) an EAE prevalence of 73% was reported.

Currently, it is estimated that nearly 315,000 people aged >15 years surf in NZ,[18,19] a participation rate that has doubled since the study by Chaplin and Stewart[17] was published.[20] The occurrence of EAE is a concern, and given the adverse effects of EAE and the limited data on its prevalence, further research on its prevalence in NZ surfers is warranted. Therefore, the aim of this study was to determine the lifetime prevalence of EAE in NZ surfers.

Methods

We conducted a national web-based, descriptive cross-sectional epidemiological study of NZ recreational and competitive surfers. An online questionnaire was created and distributed using a web-based application (SurveyMonkey, Palo Alto, CA, USA). The questionnaire was modified from a previous study of Australian surfers[21] and included two sections. Section 1 included questions about gender, age, years of surfing, participation type (recreational surfers were defined as surfers who had never participated in a competition and competitive surfers as surfers who had competed at local, national or international levels) and surfing exposure (hours surfed per week during summer and winter). Additionally, surfing skill level was determined using a modified version of the Hutt Scale.[22] Section 2 included questions related to surfing injuries (traumatic and gradual onset), as well as questions pertaining to history of unilateral or bilateral EAE diagnosed by their doctor.

Survey questions consisted of single choice, multiple choice, dropdown list, numerical input and short answer free text. Filters and this array of questions were used to abbreviate response times and minimise incomplete responses.

The study was promoted via newspaper articles, surf report websites, social media (free and paid advertisements) and through board-rider clubs and community notice boards. Participants in the study defined themselves as surfers currently in NZ. Only respondents who had more than 12 months' surfing experience were included in the analysis.

The study was approved by the Unitec Research Ethics Committee in accordance with the ethical standard of the Helsinki Declaration (UREC 20151032).

Statistical analyses

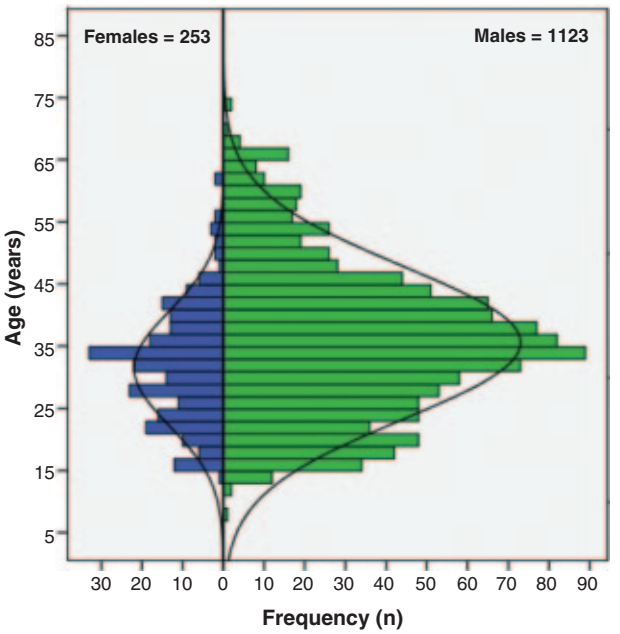
Data were initially analysed descriptively with means ± standard deviations (s.d.), count (*n*) or percent (%). Normality of all data were assessed by investigating kurtosis, skewness, QQ plots, as well as the Kolmogorov Smirnov test with the Lilliefors significance correction. Heteroscedasticity was also assessed using Levenes test for the equality of variances. Statistical significance of differences between genders was determined using independent samples *t*-tests with α set (*a priori*) to $P < 0.05$. A Pearsons correlation was utilised (where appropriate) to determine relationships. Chi-square tests and binomial logistic regression were also conducted where appropriate. All data analyses were completed using SPSS (Ver 24.0, SPSS Inc., Chicago, IL, USA).

Results

A total of 1473 participants completed the questionnaire, of whom 1376 (93.4%) completed the exostoses questions and are reported in this study. Most respondents (~95%) completed the questionnaire online, and others completed it face-to-face with one of the researchers at popular surf breaks. Most participants currently resided in NZ (for at least 6 of the previous 12 months). Of all participants, most mainly surfed in the North Island (86%), with almost one-third surfing mostly in the Auckland region (31%). The most commonly identified ethnic group(s) were NZ European (85% of participants) and Māori (12%).

Participant ages ranged from 8 to 74 years: males 8 – 74 years ($n = 1123$), females 13 – 62 years ($n = 253$) (Fig. 1).

Figure 1. Population pyramid of participants (line of normality indicated).



Median surfing experience was 13 years (interquartile range (IQR) 8 – 28 years), with most (57.1%) classified as advanced or expert surfers. They spent a median 130 h surfing (IQR 55 – 276 h), with 28% of these hours happening during winter in the previous 12 months. Table 1 shows participant characteristics by gender.

The lifetime prevalence of EAE in the surfers (recreational and competitive) was 28.9%, with males having a significantly higher ($P < 0.001$) lifetime prevalence than females (Table 2). The youngest surfer to report having EAE was a 13-year-old female, who started surfing at the age of 5 years. Mostly, reported EAE was bilateral (73.8% of EAE cases, $P < 0.001$), with no statistically significant difference in prevalence between left and right ears (Table 2).

Competitive surfers reported a significantly higher lifetime prevalence of EAE than recreational surfers (45.3% vs. 19.2%, $P = 0.001$). We identified a significantly higher lifetime prevalence of EAE as skill level increased (7.1% in beginners, 14.5% in intermediate surfers, 33.6% in advanced surfers and 55.6% in experts $P < 0.001$). When we evaluated the highest and lowest quartiles of surfing exposure (>276 h per

Table 1. Demographics of participants

Variable	Total (*n* = 1376)	Males (*n* = 1123)	Females (*n* = 253)
Age (years)	34.9 ± 11.8	35.7 ± 12.3	31.5 ± 9.2 **
Weight (kg)	78.0 ± 14.0	81.5 ± 12.5	62.7 ± 8.9 **
BMI (kg/m^2)	24.8 ± 4.3	25.2 ± 4.1	22.8 ± 4.3 **
Surfing experience (years)	16.2 ± 11.2	17.8 ± 11.2	9.3 ± 8.3 **
Surfing location • North Island • South Island	 85.8 13.2	 85.3 13.7	 88.1 10.7
Surfing status (*n*) • Recreational • Competitive	 63.1 36.9	 60.9 39.1	** 72.7 27.3
Surfing level • Beginner • Intermediate • Advanced • Expert	 13.4 29.5 37.0 20.1	 7.5 26.5 42.2 23.8	** 39.5 42.7 13.8 4.0
Total surfing (h/year)	214 ± 250	226 ± 254	163 ± 228 **
Percent surfing in winter (%/year)	28.6 ± 18.7	29.8 ± 18.1	23.2 ± 20.2 **

Values are presented as mean (± standard deviation).
BMI (body mass index)
*P < 0.05; **P < 0.001 for between-gender difference.

Table 2. Lifetime prevalence of exostoses

Variable	Total (*n* = 1376)	Males (*n* = 1123)	Females (*n* = 253)
Exostoses	397 (28.9)	360 (32.1)	37 (14.6)**
Bilateral exostoses	293 (21.3)	270 (24.0)	23 (9.1)
Unilateral exostoses • Left ear • Right ear	104 (7.6) 47 (3.4) 57 (4.1)	90 (8.0) 42 (3.7) 48 (4.3)	14 (5.5) 5 (2.0) 9 (3.6)

Values are presented as *n* (%).
** P < 0.001 for between-gender difference (exostoses only).

year and 5.15 h per year), we found a two-fold higher lifetime prevalence of EAE in the highest quartile compared to the lowest quartile (119 surfers, 34.5%, vs. 60 surfers, 17.4% P < 0.001). Because cold water exposure might influence EAE, we also compared the lifetime prevalence of EAE between highest and lowest quartiles of winter surfing exposure and between North and South Islands. Small differences in EAE prevalence between highest and lowest quartile of winter surfing exposure (34.2% vs. 25.0%, P = 0.2) and North and South Island (28.5% vs. 30.9%, P = 0.7) did not attain statistical significance.

Seventy-seven per cent of the surfers reported surfing for >5 years, and this group had a significantly higher (P < 0.001) prevalence of EAE (35.3%) than surfers with <5 years' experience. Binomial logistic regression was performed to ascertain the effects of surfing for >5 years on the prevalence of EAE. The logistic regression model was statistically significant, $\chi 2 = 119.051$, P < 0.001, and correctly classified 71.3% of cases. Participants who surfed for >5 years had 7.4-fold higher odds of reporting exostosis than surfers who had not surfed for this length of time. Table 2 shows our findings with regard to exostoses reported by participants.

Discussion

The aim of this study was to identify the lifetime prevalence of EAE in NZ surfers. We surveyed 1376 surfers and, to the best of our knowledge, it is the largest cohort to date to be screened for EAE in NZ and the most representative of the NZ surfing population. The Māori proportion of surfers was only slightly less than the Māori proportion (15%) reported in the 2013 NZ Census.[23] Our findings revealed a prevalence of 28.9%, with nearly three-quarters of affected surfers reporting the condition bilaterally. This suggests that EAE has the potential to affect nearly 100,000 surfers in the country. This number is likely to rise, due to the increasing popularity of surfing in NZ, which is mainly attributed to the countrys coastline, allowing easy access to a range of good-quality surf breaks.[24]

Described since the 1800s,[25] EAE has been associated with water sports from the early stages of its investigation.[26] In an anthropological study,[27] the condition was found to be more prevalent in populations who depended on aquatic resources and lived between the latitudes of 30° and 45° North and South, where the annual mean water temperature is below 19°C. NZ is geographically located below the latitude of 30° south, with most of the country's coastline situated between 35° and 45°.[28] The highest annual mean surface water temperatures is ~17°C, measured in sites in Auckland and

Northland, in the North Island.[13] Therefore, NZ surfers are exposed to conditions conducive for the development of EAE.

The first study of the prevalence of EAE in NZ was conducted in 1994[17] and reported a prevalence of 73%. Today, this would represent nearly 230,000 surfers having the condition, a number more than two-fold higher than we found in this study. Chaplin and Stewart[17] reported that 92% of people surfing for more than 10 years had developed exostoses. The mean surfing experience of our cohort was 16.2 years, so we expected to find a higher prevalence than we actually observed. The discrepancy between the results of these two studies could be partially explained by the fact that most surfers in our study (86%) were from the North Island, with almost one-third from the Auckland region (mean water temperature of ~17°C),[13] whereas 92% of the participants investigated by Chaplin and Stewart[17] were from the South Island, with many probably local to the Otago area (mean water temperature of ~12°C).[13] A strong association between cold-water exposure and EAE has been reported in the literature.[5,27,29,30] However, the present investigation was unable to demonstrate this correlation, as there was a non-significant difference between highest and lowest quartiles for winter hours surfing exposure and exostoses. Chaplin and Stewart[17] noted that the seven surfers from the North Island had less severe exostoses than surfers from the South Island, despite a similar exposure of surfing in winter ($P < 0.005$) however, they did not report differences between islands in EAE prevalence. Similarly, in the present study, we found no difference in lifetime EAE prevalence between surfers who mainly surfed in the North versus South Islands and no difference in prevalence according to time spent surfing in winter months.

Another explanation for the difference in EAE prevalence noted here and previously could be related to the methods used to assess EAE. Chaplin and Stewart[17] examined participants via operating microscope by two assessors, who assessed the presence and severity of EAE. In our study, surfers answered a questionnaire where they were asked whether they had previously had EAE diagnosed by a doctor. An even larger disparity in the prevalence of EAE was noted in two Australian studies.[31,32] A study assessing self-reported surfing injuries, but not specifically questioning about EAE, found that only 3.5% reported having a surfing-related ear injury.[31] This is in contrast to another study,[32] where the condition was assessed by otoscopy and found a prevalence of 76%. The dissonance between self-reported and externally assessed prevalence may suggest low awareness of surfers about the condition, yielding concerns with respect to the condition being overlooked by health practitioners.

Previous research has established that exostoses are highly correlated with the amount of time spent in the water, with risk increasing after five sessions of surfing per month, and significantly increasing after 5 years of surfing.[10,11] We found that surfers in the highest quartile of surfing exposure had a two-fold increase in the prevalence of EAE. Consistent with the literature, we found that participants who reported surfing for >5 years had a higher prevalence of EAE than surfers who had surfed for < 5 years, having more than a seven-fold higher risk of developing the condition. Although the age of the youngest surfer to report having EAE in our study was aged 13 years, she had 8 years of surfing experience.

Traditionally, EAE is more commonly found bilaterally[1] and we also found that nearly 74% of the surfers with EAE had both ears affected by the condition, with no difference between left and right ears. This finding is also consistent with other research[17] reporting that statistically both ears were affected in the same proportion.

Two strengths of this study are the large sample size and the relatively high response rate that could be obtained from a survey strategy taking advantage of close networks among the New Zealand surfing community. These features are likely to reduce response bias, and allow for more accurate estimates of prevalence. Furthermore, we conducted a national survey, aiming to reach a representative spread of individuals throughout the country, which included recreational and competitive surfers. However, several limitations

should be acknowledged. First, the prevalence of EAE was based on self-reported information and not on otologic examination, and therefore the prevalence reported here may be underestimated. Additionally, this design did not allow us to gather data on the severity of the condition. Almost all participants currently resided in NZ and had lived in the country for 6 of the previous 12 months. This population might therefore have included surfers who had previously lived in places where surf conditions, such as warm water, may be associated with a lower prevalence of exostoses. Past movement between regions may also explain lack of difference between those who currently mainly surf in the North and South Islands. Third, we did not include questions related to the use of protective equipment. Protective equipment is recommended by the American Academy of Family Physicians,[7] but Chaplin and Stewart[17] reported no difference in EAE prevalence between surfers who wore protective earplugs and those who did not. Finally, we did not account for participation in other water activities notwithstanding, the study by Chaplin and Stewart[17] reporting no significant difference between individuals who engaged in other water sports and those who did not.

The results of this study have shown that the prevalence of EAE, although lower than a previous study assessing NZ surfers in the southern region of the country, is likely to affect nearly 100,000 individuals in NZ. Moreover, we demonstrated that individuals surfing for >5 years have an increased risk of developing exostoses, and the lesions can start developing at an early age, as early as 13 years. There is, therefore, a need for awareness in general practice of EAE risk for individuals who surf, aiming at prevention, early treatment or appropriate referral for people with this condition. Further research should focus on assessing surfers via otologic examination, determining not only the prevalence but also severity of the condition.

Author Contributions

All authors declare that they have made a substantial contribution based upon guidelines developed by the International Committee of Medical Journal Editors (http://www.icmje.org/recommendations/browse/roles-and-responsibilities/defining-the-role-of-authors-and-contributors.html).

Competing Interests

The authors declare no competing interests.

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